



US008581259B2

(12) **United States Patent**  
**Chen et al.**

(10) **Patent No.:** **US 8,581,259 B2**  
(45) **Date of Patent:** **Nov. 12, 2013**

(54) **DISPLAYING DEVICE WITH PHOTOCURRENT-REDUCING STRUCTURE AND METHOD OF MANUFACTURING THE SAME**

(75) Inventors: **Tung-Yu Chen**, Tainan (TW);  
**Liu-Chung Lee**, Pingtung County (TW)

(73) Assignee: **AU Optronics Corp.**, Hsin-Chu (TW)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1317 days.

(21) Appl. No.: **11/254,726**

(22) Filed: **Oct. 21, 2005**

(65) **Prior Publication Data**

US 2006/0273318 A1 Dec. 7, 2006

(30) **Foreign Application Priority Data**

Jun. 1, 2005 (TW) ..... 94118075 A

(51) **Int. Cl.**

**H01L 27/14** (2006.01)  
**H01L 29/04** (2006.01)  
**H01L 29/15** (2006.01)  
**H01L 31/036** (2006.01)

(52) **U.S. Cl.**

USPC ..... **257/72; 257/59; 349/38; 349/39; 349/42; 349/122; 349/138; 349/142**

(58) **Field of Classification Search**

USPC ..... **257/59, 72; 349/38, 42, 122, 138, 142**  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,478,766	A	12/1995	Park et al.	
6,144,422	A	11/2000	Lee	
6,278,504	B1 *	8/2001	Sung	349/46
7,088,401	B1 *	8/2006	Ihara et al.	349/39
2002/0171782	A1 *	11/2002	Yee et al.	349/43
2005/0140836	A1 *	6/2005	Choi	349/40
2007/0052020	A1 *	3/2007	Chen et al.	257/347

FOREIGN PATENT DOCUMENTS

CN	1165568	A	11/1997	
CN	1405865	A	3/2003	

\* cited by examiner

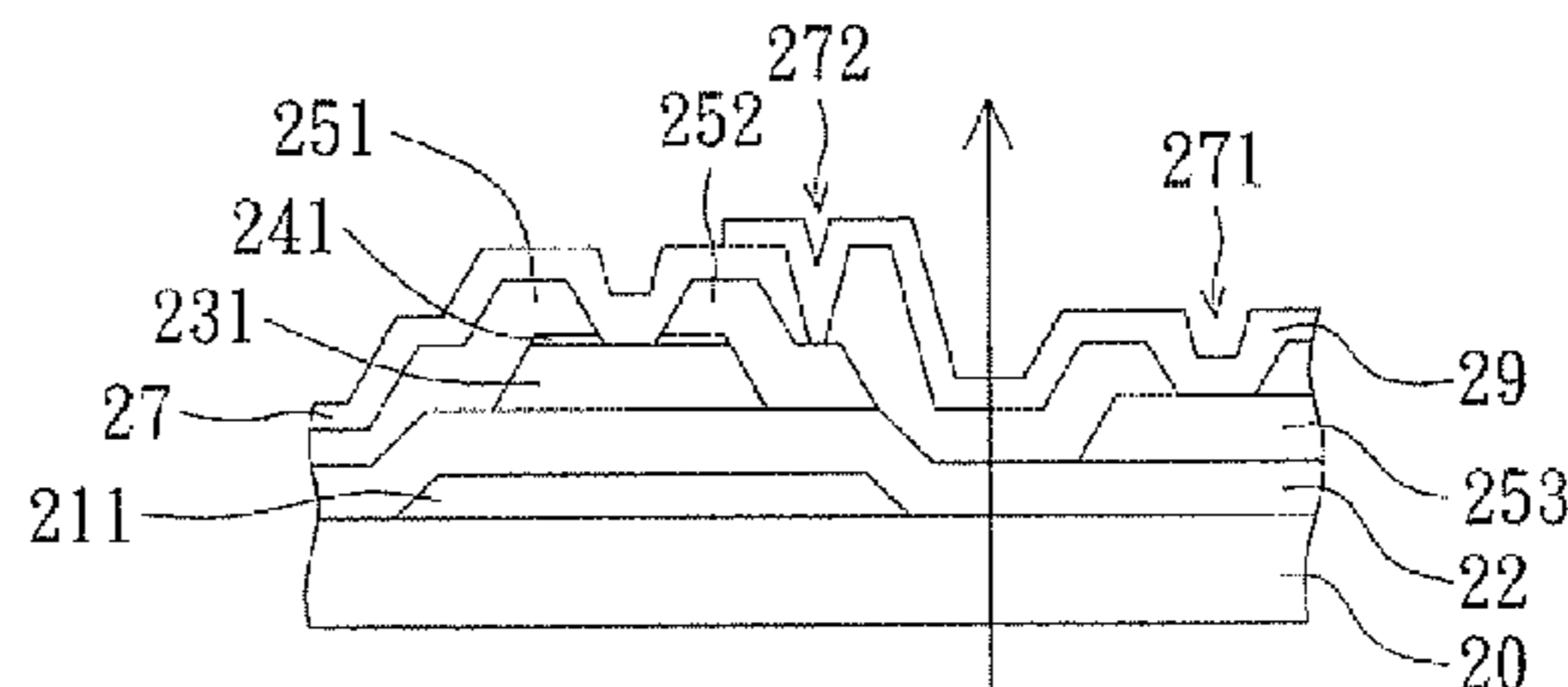
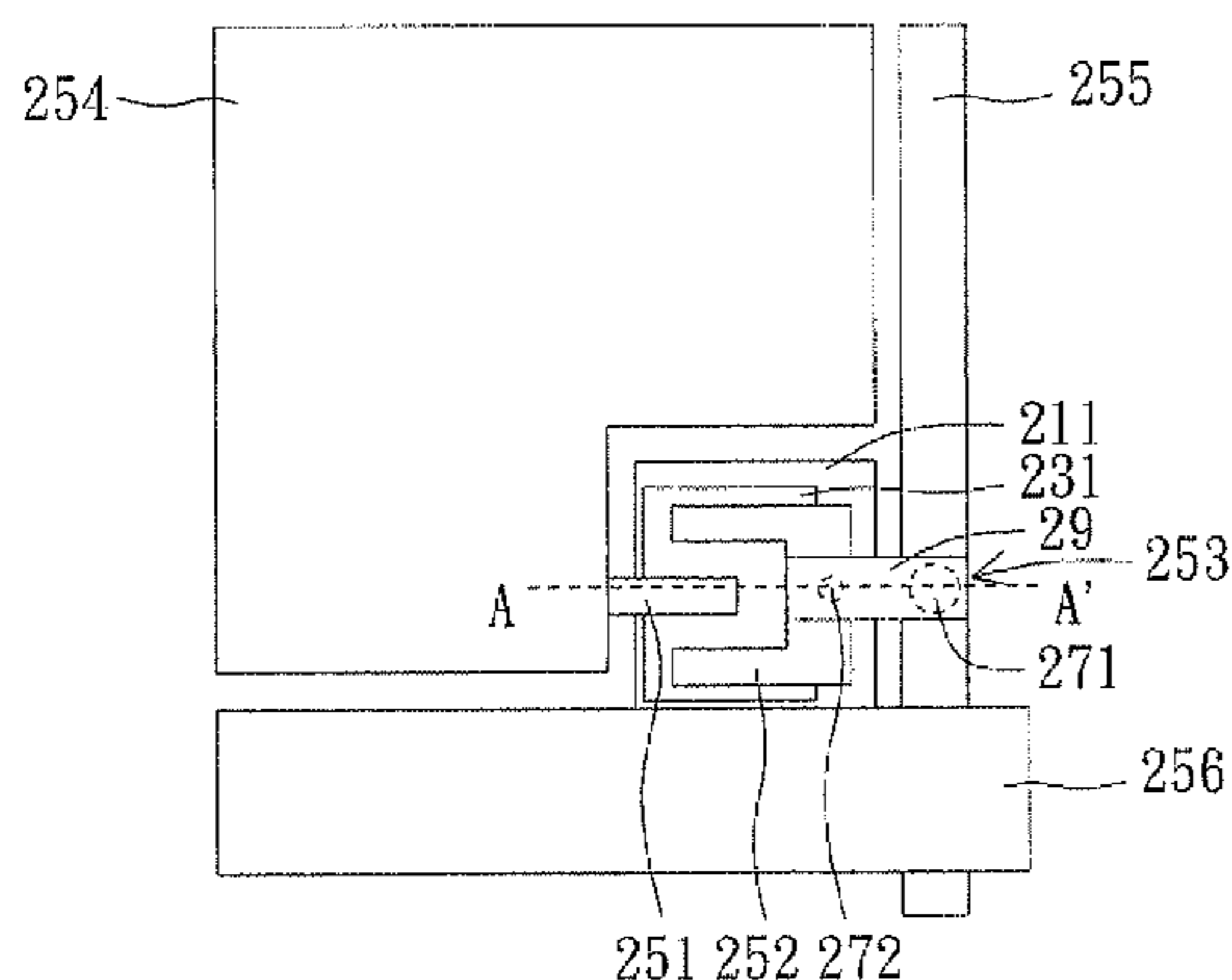
*Primary Examiner* — Meiya Li

(74) *Attorney, Agent, or Firm* — Bacon & Thomas, PLLC

(57) **ABSTRACT**

A displaying device includes a substrate, a gate electrode formed on the substrate, a gate insulating layer, a gate a-Si region covering the gate electrode, a source metal region, a drain metal region, a data-line (DL) metal region, a passivation layer and a conductive layer. The gate a-Si region is formed on the gate insulating layer. The source and drain metal regions are formed on the gate a-Si region. The DL metal region is formed on the gate insulating layer and separated from the drain metal region at an interval. The passivation layer formed on the gate insulating layer covers the source, drain, and DL metal regions. The first and second vias of the passivation layer expose partial surfaces of the DL and drain metal regions respectively. The conductive layer formed on the passivation layer covers the first and second vias for electrically connecting the DL and drain metal regions.

**14 Claims, 6 Drawing Sheets**



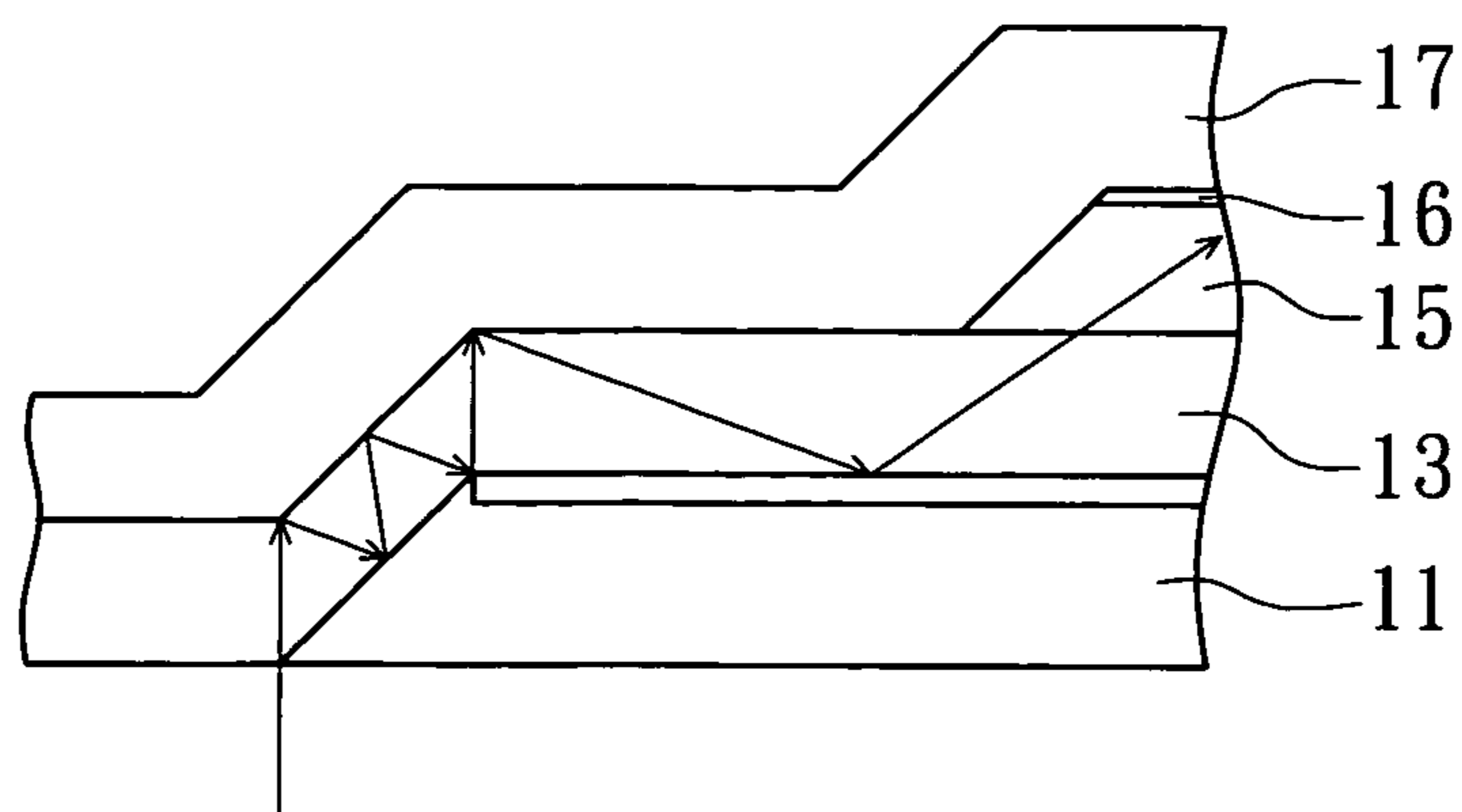


FIG. 1 (RELATED ART)

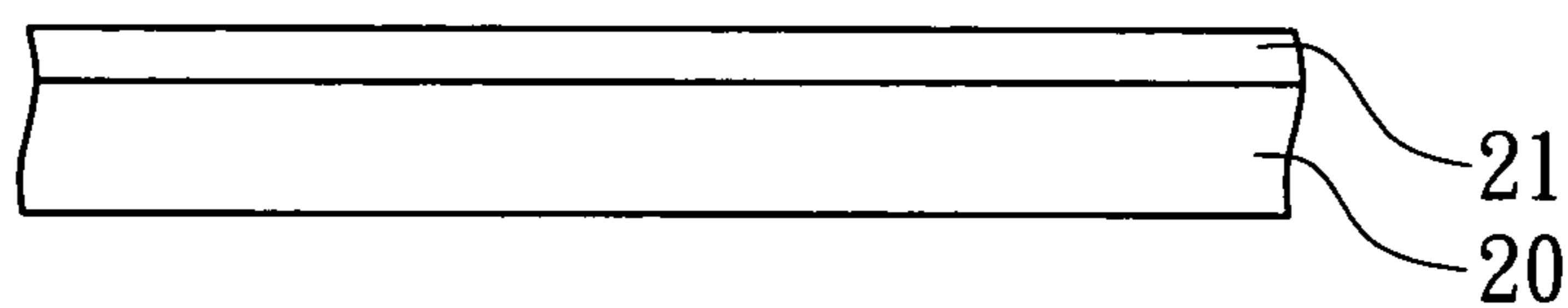


FIG. 2A

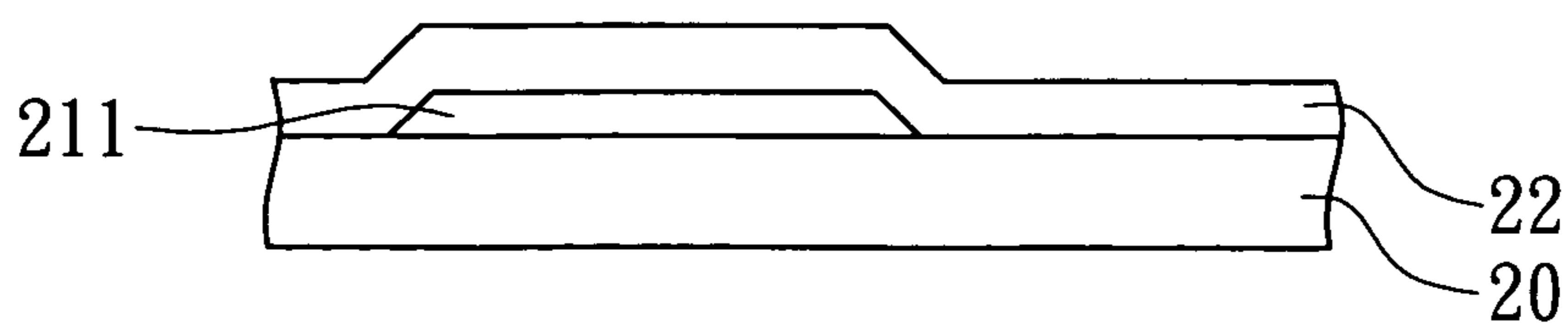


FIG. 2B

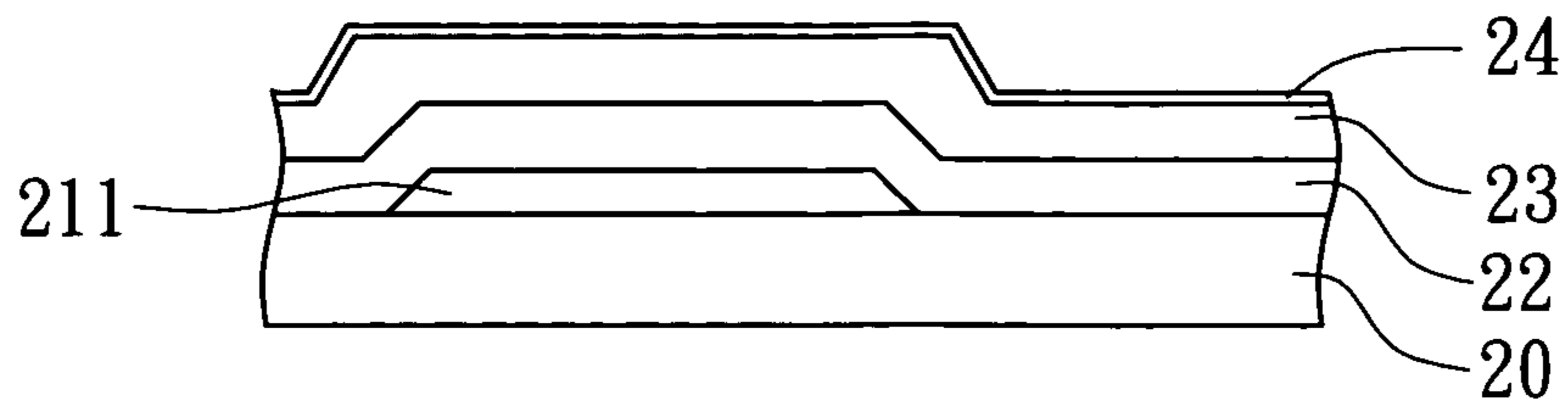


FIG. 2C

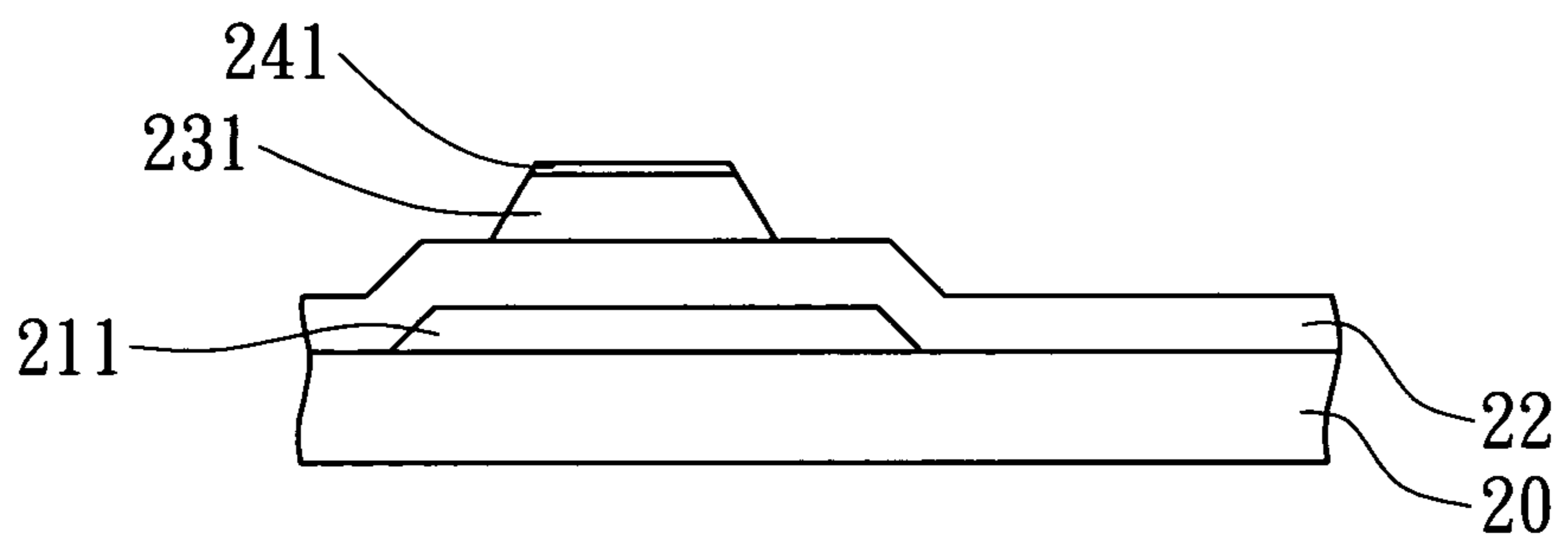


FIG. 2D

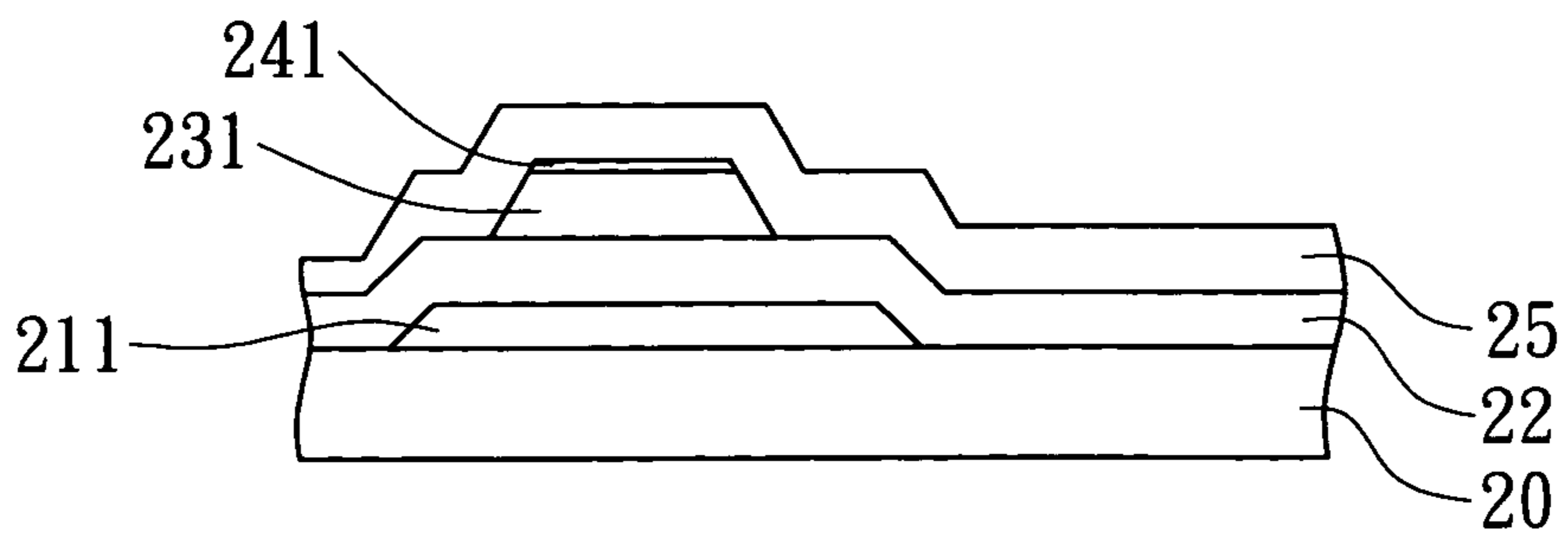


FIG. 2E

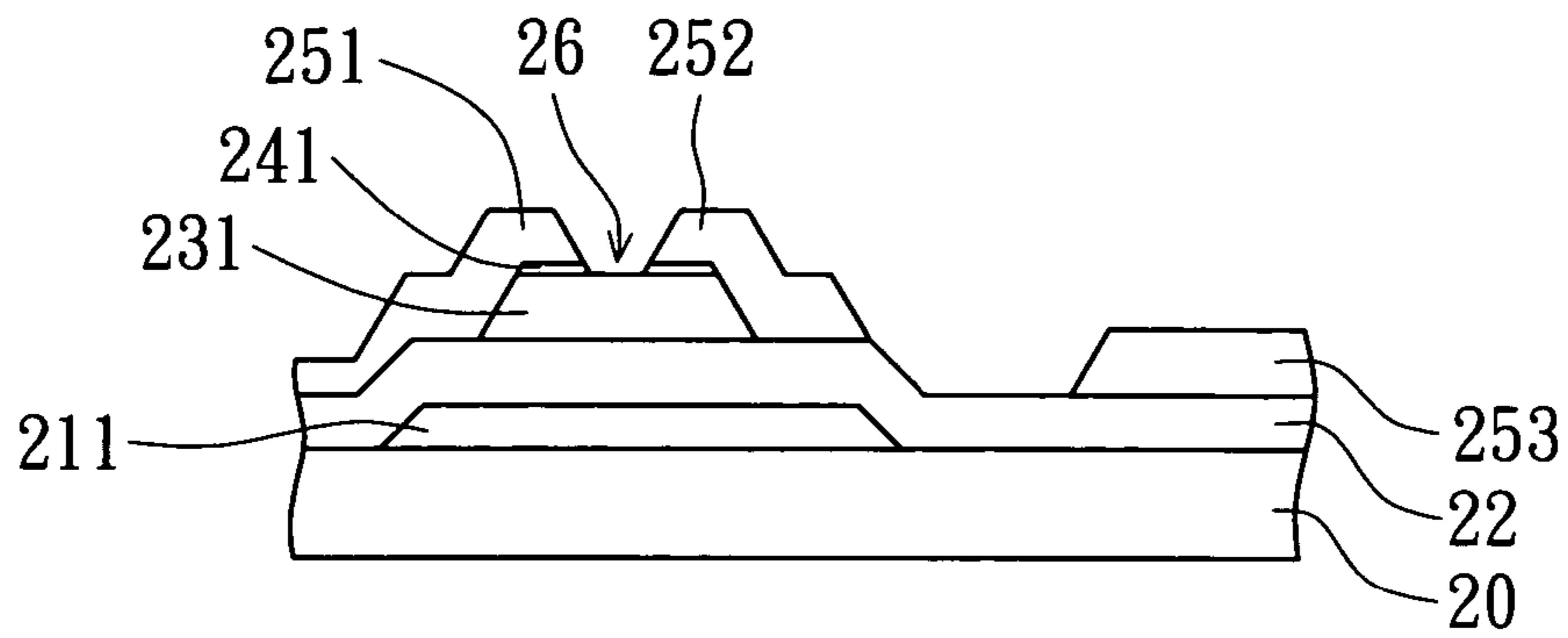


FIG. 2F

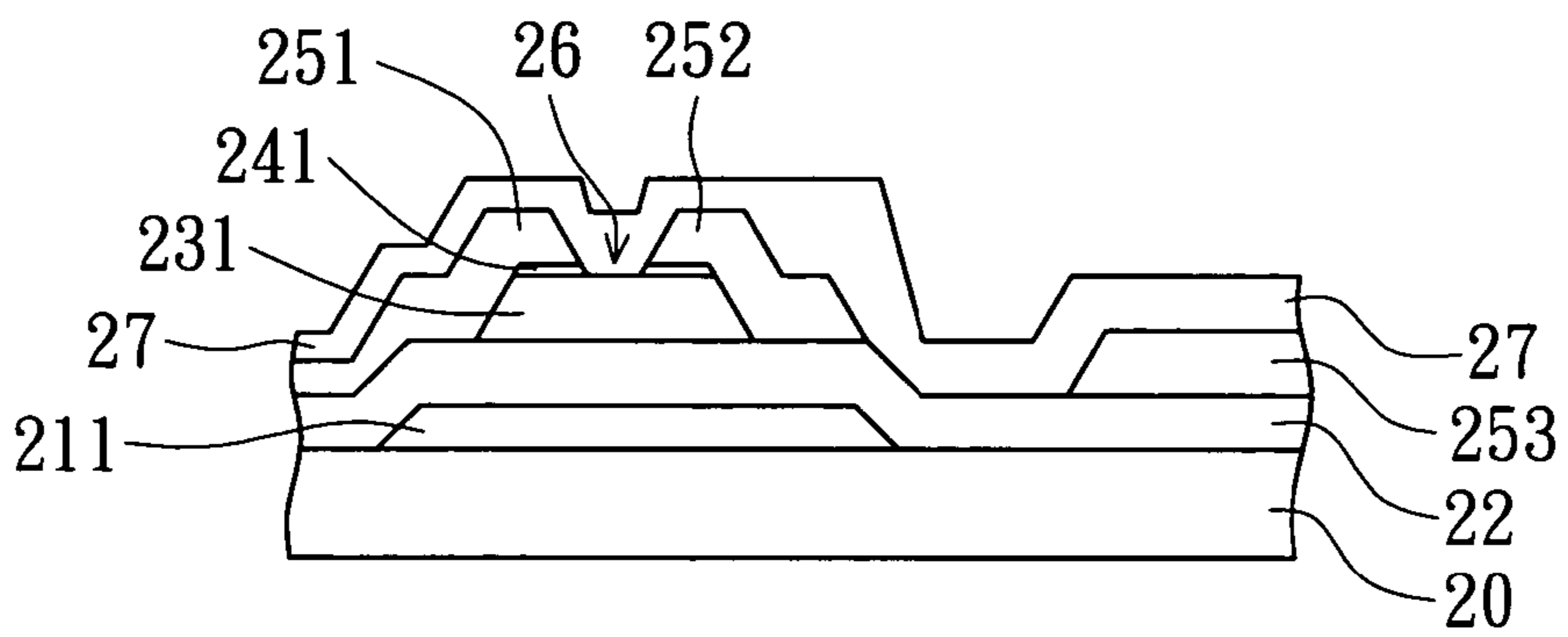


FIG. 2G

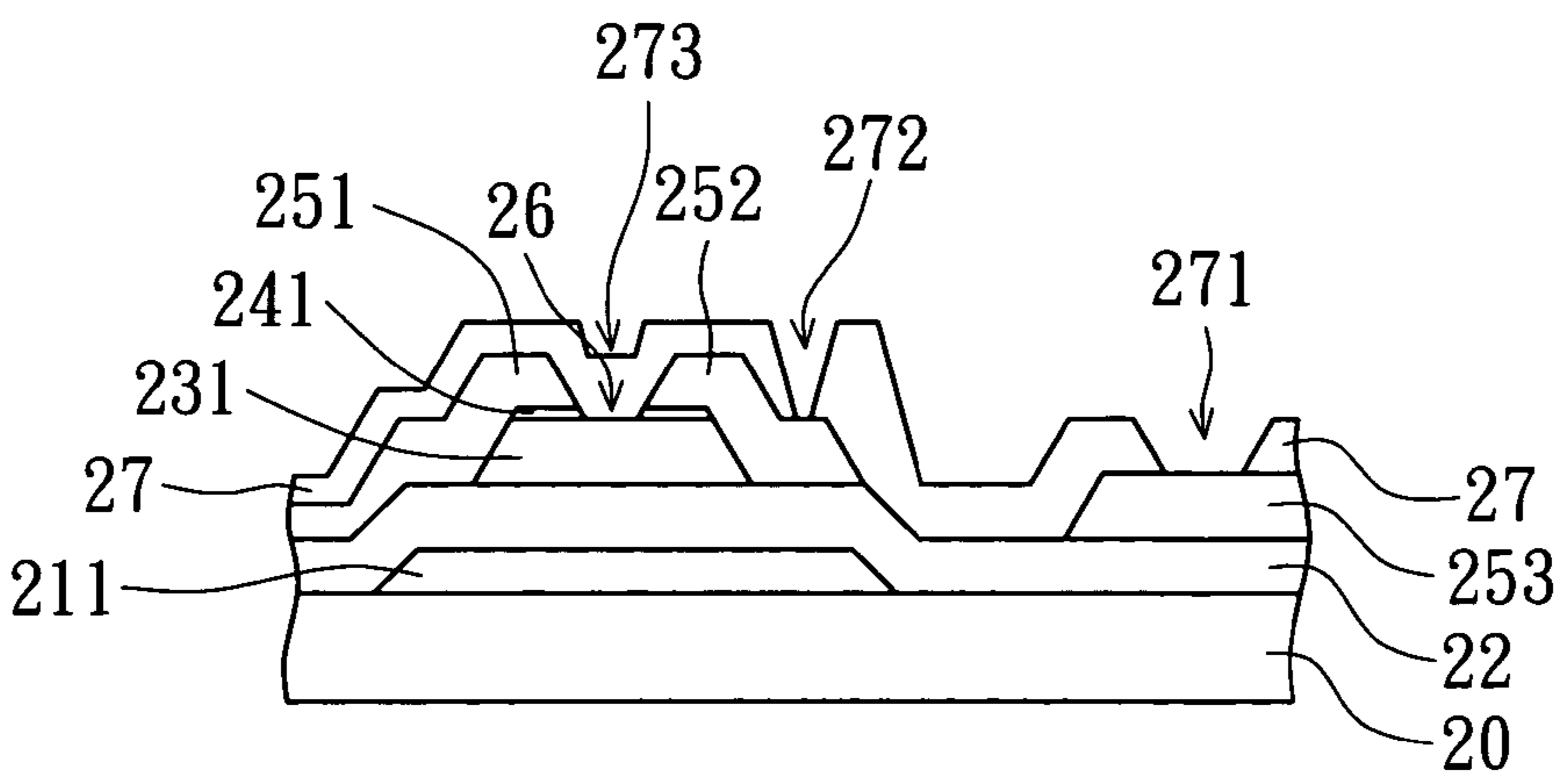


FIG. 2H

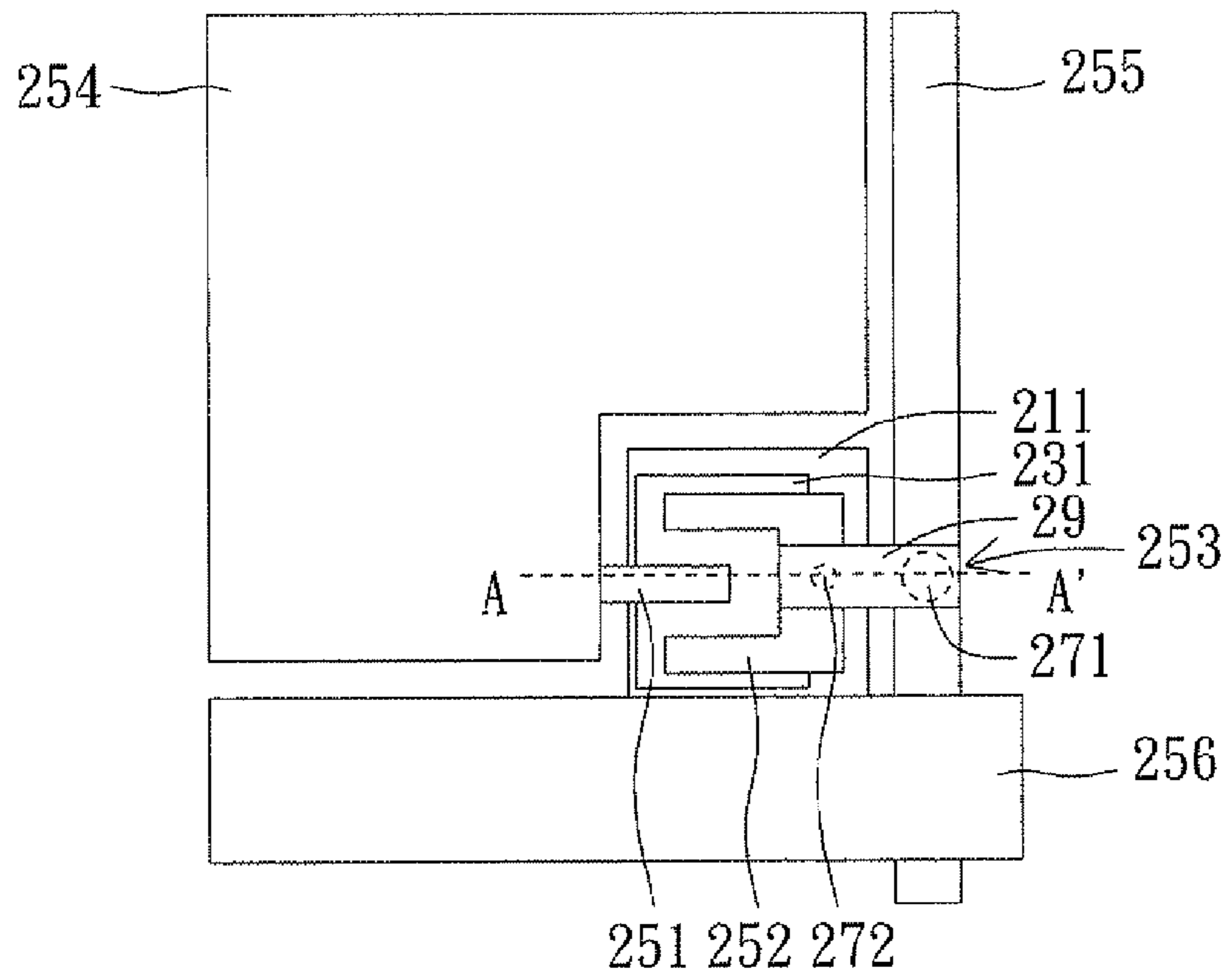


FIG. 2I

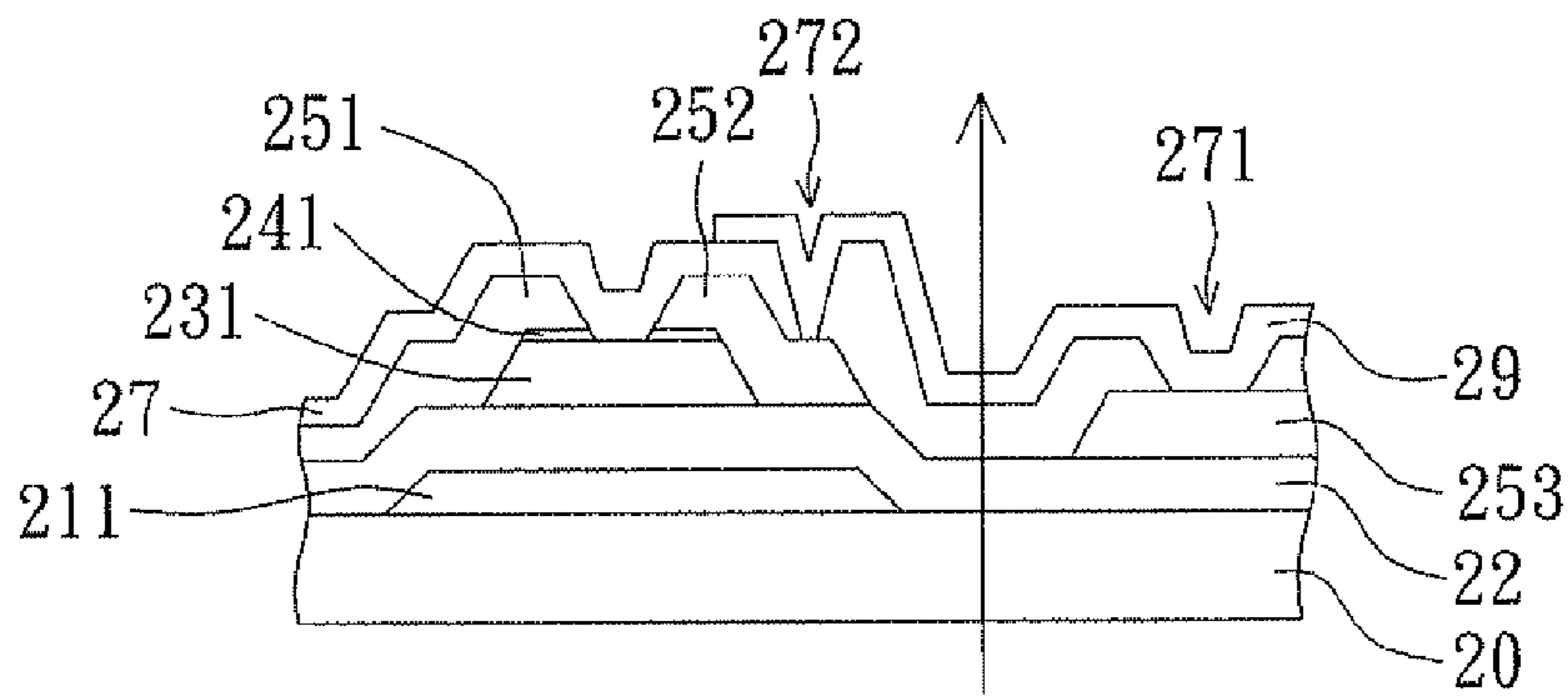


FIG. 2J

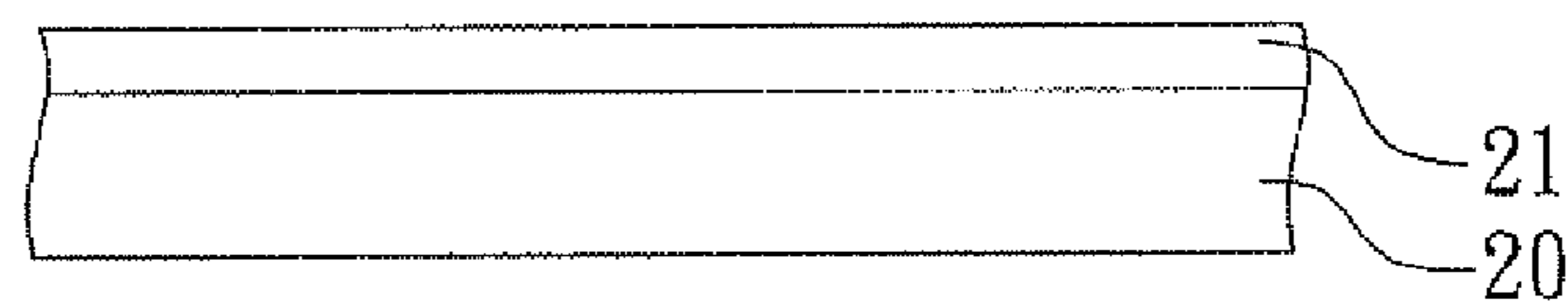


FIG. 3A

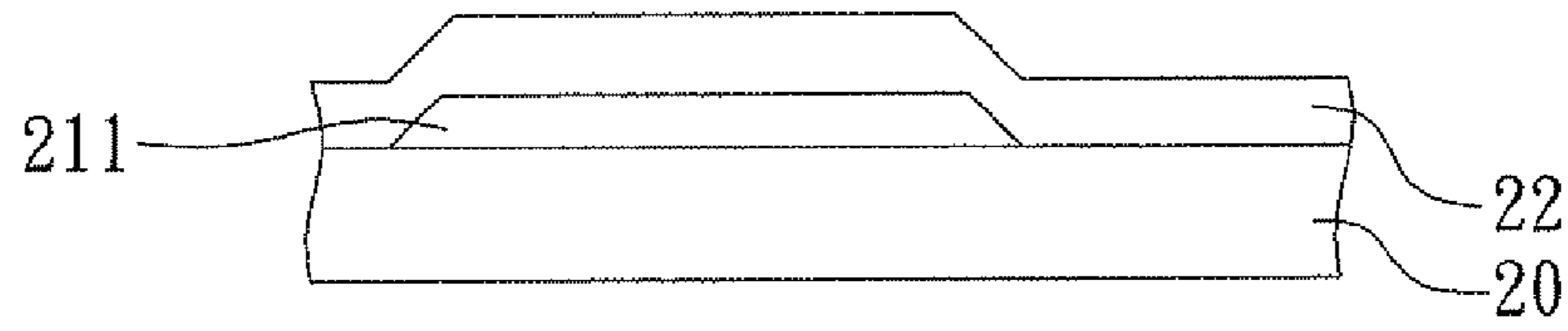


FIG. 3B

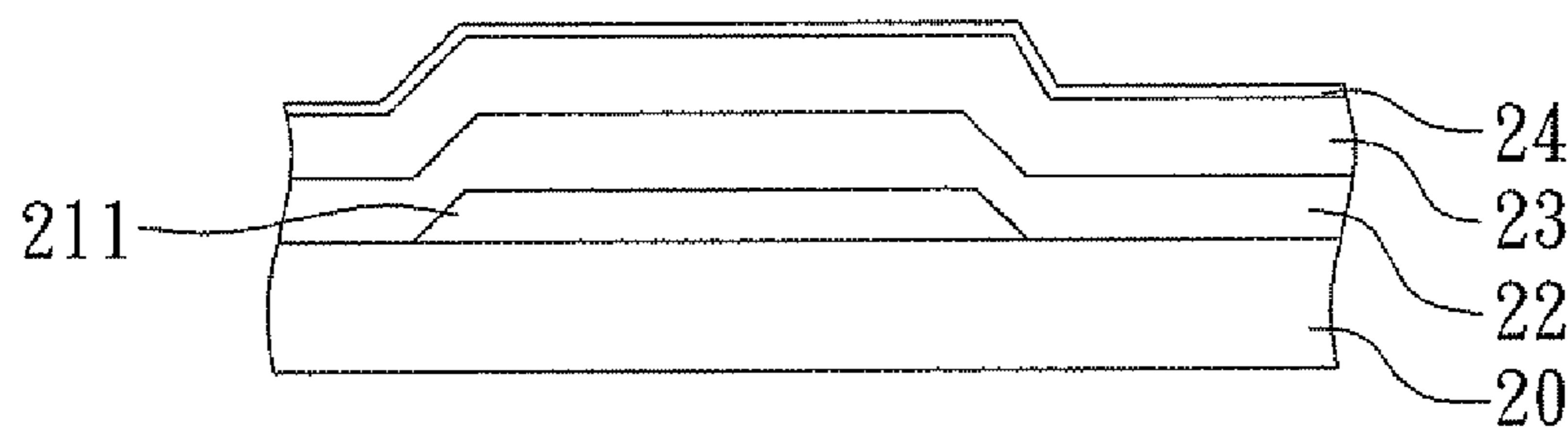


FIG. 3C

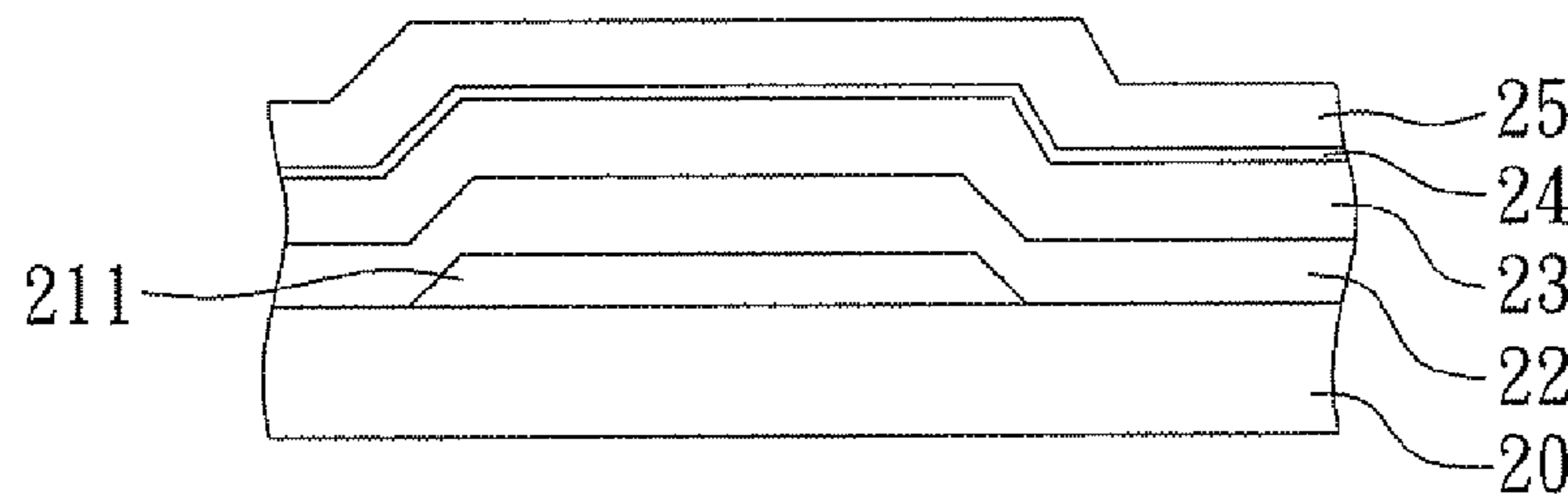


FIG. 3D

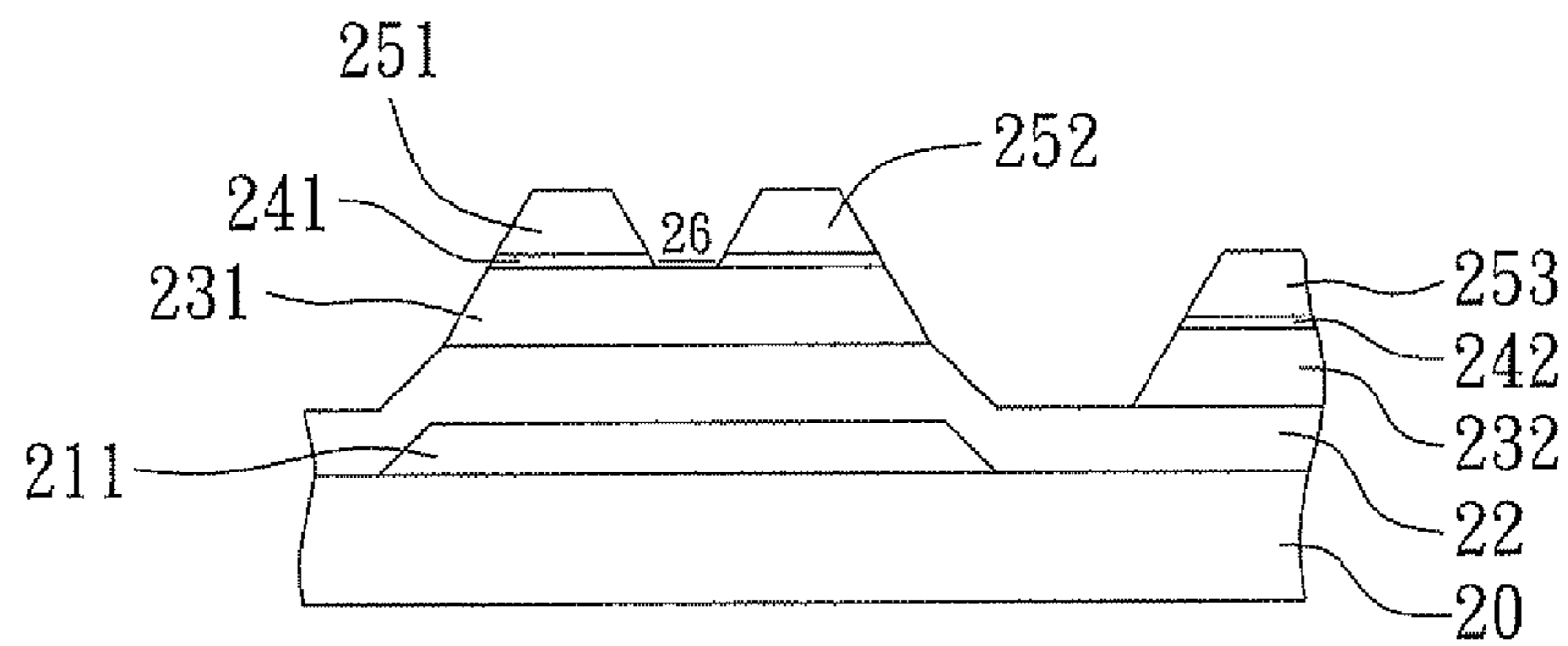


FIG. 3E

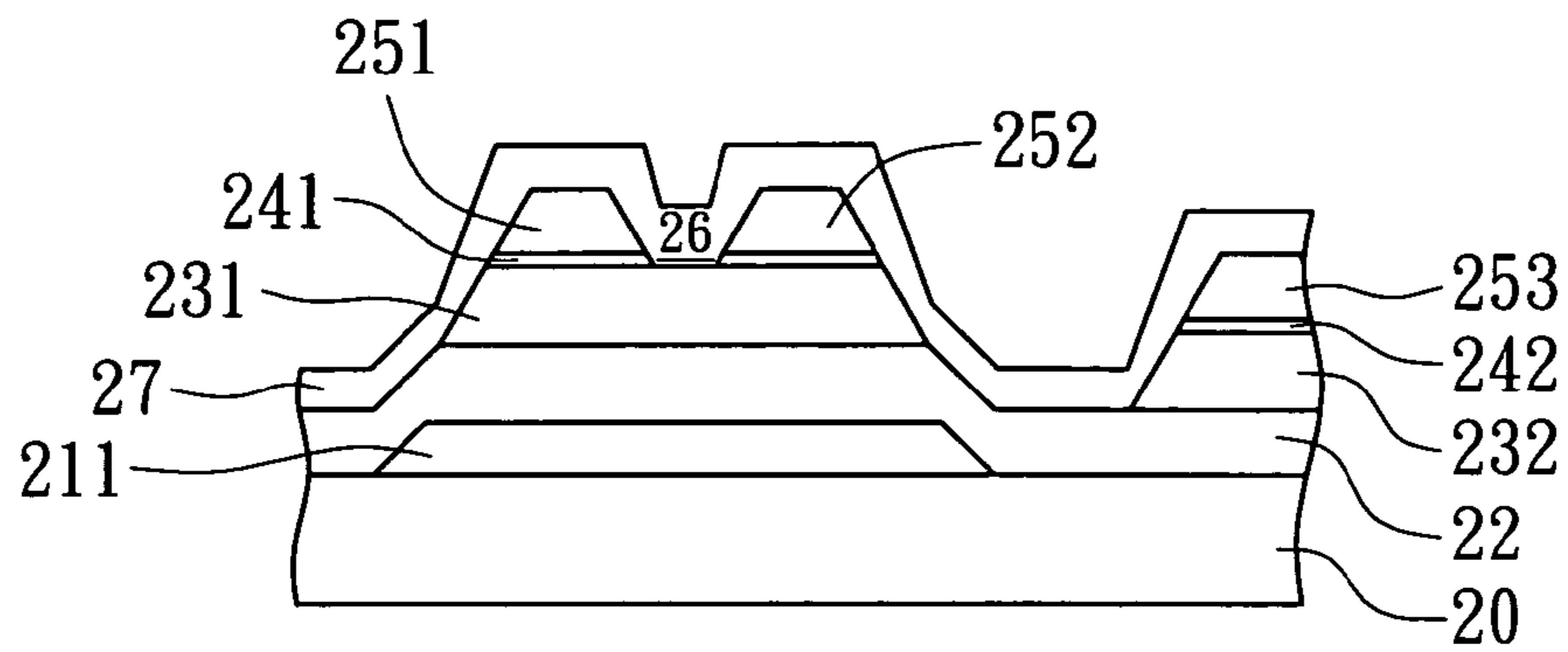


FIG. 3F

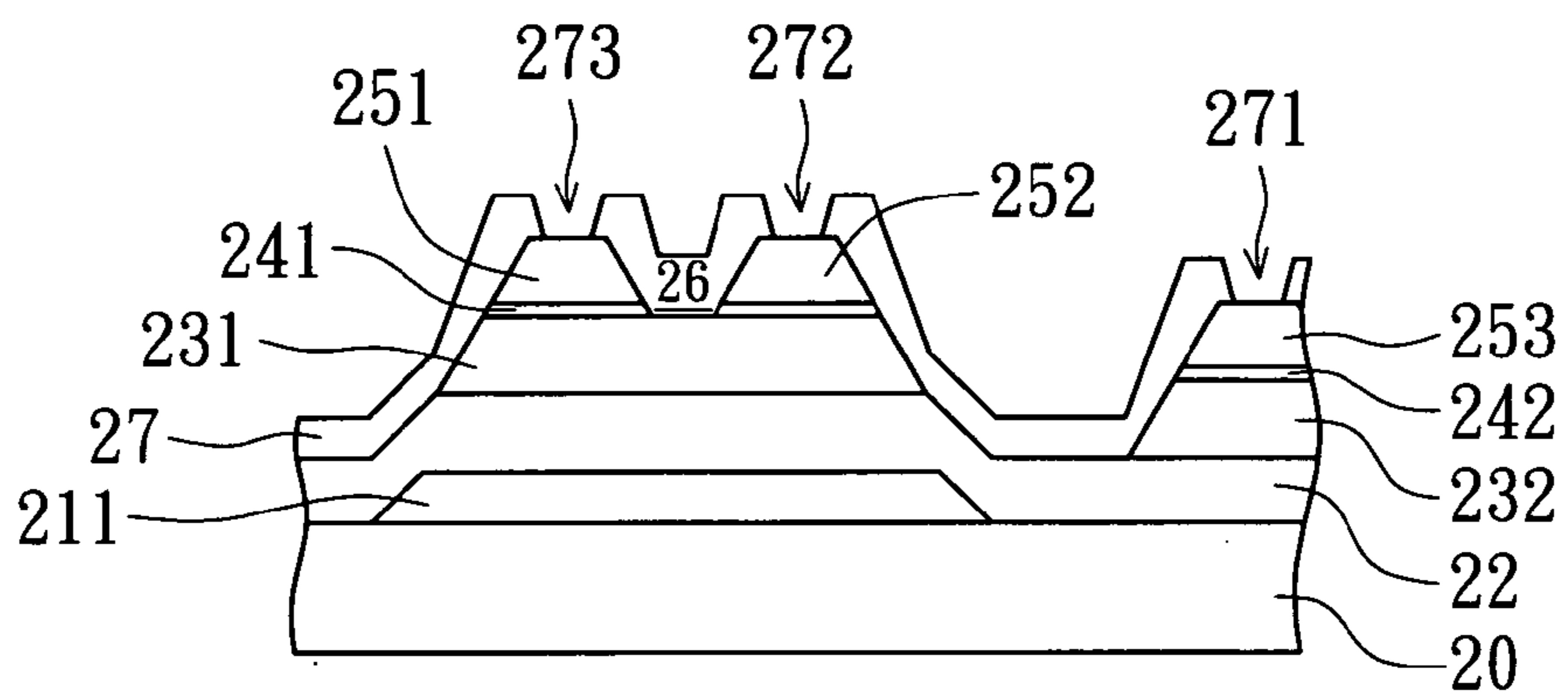


FIG. 3G

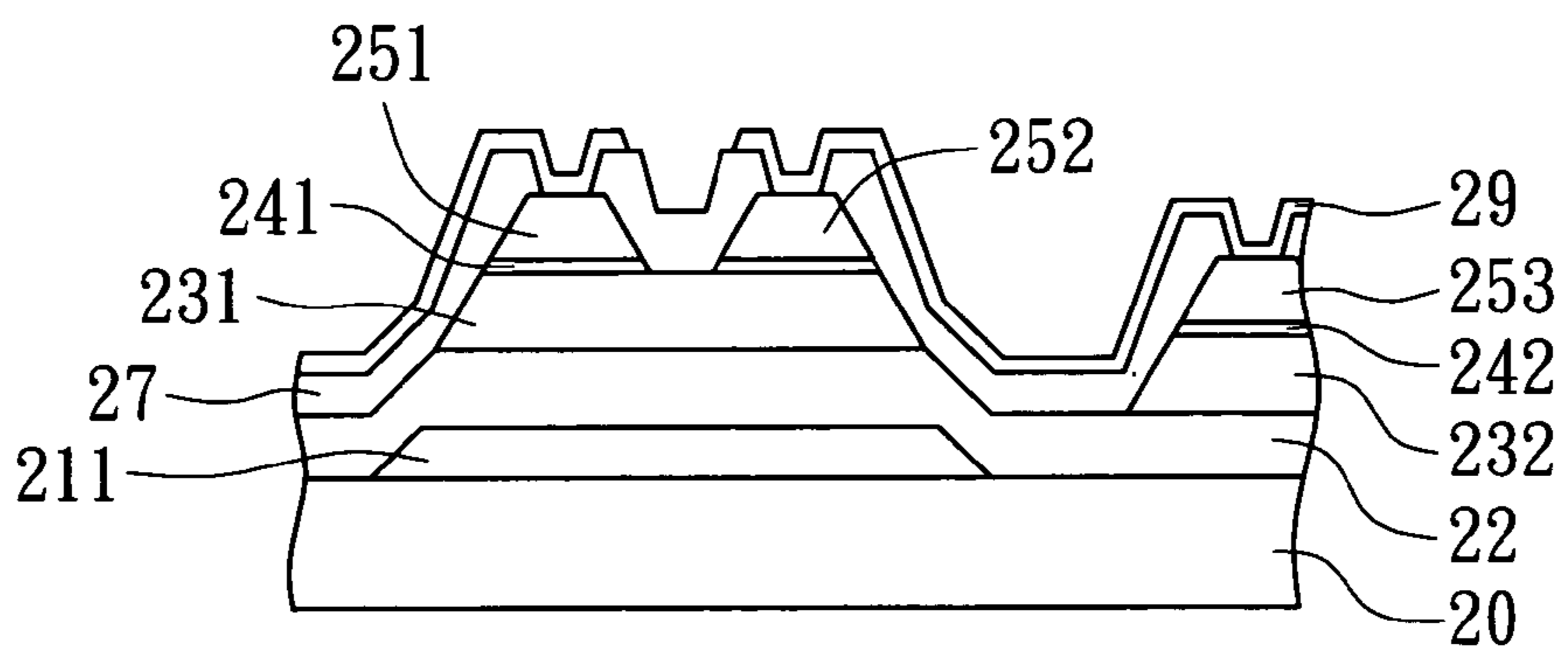


FIG. 3H

## 1

**DISPLAYING DEVICE WITH  
PHOTOCURRENT-REDUCING STRUCTURE  
AND METHOD OF MANUFACTURING THE  
SAME**

This application claims the benefit of Taiwan application Serial No. 94118075, filed Jun. 1, 2005, the subject matter of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates in general to a displaying device and a method of manufacturing the same, and more particularly to a displaying device with photocurrent-reducing structure and a method of manufacturing the same.

2. Description of the Related Art

Normally, displaying devices such as thin film transistor LCD devices (TFT LCD) are manufactured according to a five-mask manufacturing process. However, during which process, the amorphous silicon (a-Si) layer is photosensitive and is likely to generate photocurrent and cause photocurrent leakage after being exposed to the light.

Referring to FIG. 1, a partial cross-sectional view of a TFT LCD device formed according to a conventional five-mask manufacturing process is shown. The array formed according to a conventional five-mask manufacturing process includes a gate electrode 11 formed by a first metal layer and disposed on a substrate, a gate insulating layer 13 made of silicon nitride, a gate electrode a-Si layer 15, an n+ a-Si layer 16 and a source electrode 17 formed by a second metal layer as shown in FIG. 1. A backlight module is disposed below the substrate to provide the displaying device with a light source. The photosensitivity of a-Si has already been taken into consideration when designing the five-mask manufacturing process of a TFT device, and the pattern of the a-Si layer 15 is designed to be indented into the gate electrode 11. That is, the gate electrode a-Si layer 15 can be completely blocked by the gate electrode 11 to reduce photocurrent leakage. However, part of the light would still be projected onto the gate electrode a-Si layer 15 via a reflection path, causing undesired photocurrent leakage. The reflection path 1 illustrates the reflection of the light between the first metal layer and the second metal layer as shown in arrows of FIG. 1.

In a four-mask manufacturing process, the a-Si layer and the second metal layer are formed in the same layer mask, so the a-Si layer exists under the pattern of the second metal layer. That is, the pattern of the a-Si layer can not be indented in the first metal layer. When the light of the backlight module is projected onto the second metal layer from behind the first metal layer, the light directly is projected onto the a-Si layer, causing even higher photocurrent leakage than the structure manufactured according a five-mask manufacturing process.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide a displaying device and a method of manufacturing the same for reducing photocurrent leakage of displaying device.

The invention achieves the above-identified object by providing a displaying device at least including a substrate, a gate electrode, a gate insulating layer, a g-aSi region, a source metal region, a drain metal region, a data-line (DL) metal region, a passivation layer and a conductive layer. The gate electrode is formed on the substrate, and the gate insulating layer covers the gate electrode. The g-aSi region is formed on the gate insulating layer and correspondingly positioned

## 2

above the gate electrode. The source metal region and a drain metal region are formed on the g-aSi region. The DL metal region is formed on the gate insulating layer and separated from the drain metal region at an interval. The passivation layer is formed on the gate insulating layer and covers the source metal region, the drain metal region and the DL metal region. The passivation layer includes a first via and a second via for respectively exposing partial surfaces of the DL metal region and partial surfaces of the drain metal region. The conductive layer is formed on the passivation layer and covers the first via and the second via for electrically connecting the DL metal region and the drain metal region.

The invention achieves the above-identified object by further providing a manufacturing method of a displaying device at least including the following steps of: forming a gate electrode on a substrate; forming a gate insulating layer for covering the gate electrode; forming a g-aSi region on the gate insulating layer, the g-aSi region being correspondingly positioned above the gate electrode; forming a source metal region, a drain metal region and a data-line (DL) metal region above the gate insulating layer, the DL metal region being separated from the drain metal region at an interval; forming a passivation layer on the gate insulating layer and covering the source metal region, the drain metal region and the DL metal region; forming a first via and a second via on the passivation layer for respectively exposing partial surfaces of the DL metal region and partial surfaces of the drain metal region; and forming a conductive layer on the passivation layer and covering the first via and the second via for electrically connecting the DL metal region and the drain metal region.

Other objects, features, and advantages of the invention will become apparent from the following detailed description of the preferred but non-limiting embodiments. The following description is made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 (Related Art) is a partial cross-sectional view of a TFT LCD device formed according to a conventional five-mask manufacturing process;

FIG. 2A-2J illustrate a manufacturing method of a TFT displaying device according to a first embodiment of the invention; and

FIG. 3A-3H illustrate a manufacturing method of a TFT displaying device according to a second embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The invention modifies the manufacturing process of a displaying device such as a TFT displaying device. The electrode and the data-line are disconnected first and then bridged via a transparent electrode, so that the electrode is indented in the gate electrode to reduce photocurrent leakage.

The invention is exemplified by the embodiments disclosed below. The first embodiment and the second embodiment respectively explain how to use the five-mask manufacturing process and the four-mask manufacturing process to manufacture a photocurrent-reducing TFT displaying device and the method of manufacturing the same. However, the embodiments disclosed below are not to limit the scope of protection of the invention. The technology of the invention is not limited to the modes disclosed in the embodiments.



Besides, non-critical devices are omitted in the drawings to make the embodiments of the invention prominent.

#### First Embodiment

Refer to FIG. 2A-2J, which illustrate a manufacturing method of a TFT displaying device according to a first embodiment of the invention. In the first embodiment, a five-mask manufacturing process is employed to manufacture a displaying device.

At first, a substrate **20** is provided, and a first metal layer **21** is formed on the substrate **20** as shown in FIG. 2A. Next, the first metal layer **21** is patterned to form a gate electrode **211**, and a gate insulating layer **22** is formed on the substrate **20** and covers the gate electrode **211** as shown in FIG. 2B.

Then, an a-Si layer **23** is formed on the gate insulating layer, and a doped a-Si layer (such as n+ a-Si layer) **24** is formed on the a-Si layer **23** as shown in FIG. 2C. Next, the doped a-Si layer **24** and the a-Si layer **23** are patterned to form a doped g-aSi region **241** and a g-aSi region **231**, which are correspondingly positioned above the gate electrode **211**, as shown in FIG. 2D.

Afterwards, a second metal layer **25** is formed on the gate insulating layer **22** and covers the g-aSi region **231** and the doped g-aSi region **241** as shown in FIG. 2E.

Next, the second metal layer **25** is patterned to form a source metal region **251**, a drain metal region **252** and a DL metal region **253**. A channel region **26** exists between the source metal region **251** and the drain metal region **252** which are separated at an interval from each other as shown in FIG. 2F.

Then, a passivation layer **27** is formed on the gate insulating layer **22** and covers the source metal region **251**, the drain metal region **252** and the DL metal region **253**, as shown in FIG. 2G.

Next, a first via **271** and a second via **272** are formed on the passivation layer **27** for respectively exposing partial surfaces of the DL metal region **253** and partial surfaces of the drain metal region **252** as shown in FIG. 2H.

At last, a conductive layer **29** is formed on the passivation layer **27** covers the first via **271** and the second via **272** for electrically connecting the DL metal region **253** and the drain metal region **252** as shown in FIG. 2I. The conductive layer **29** can be made of indium tin oxide (ITO) for instance.

FIG. 2I is a top view of a TFT displaying device according to the first embodiment of the invention. FIG. 2J is a cross-sectional view of the TFT displaying device along the line A-A' of FIG. 2I. In the first embodiment, as shown in FIG. 2I, the source metal region **251** is coupled to a pixel electrode **254**, the DL metal region **253** is coupled to a data line **255** and the gate electrode **211** is coupled to a gate line **256**. The DL metal region **253** and the drain metal region **252** are electrically isolated, that is, the second metal layer **25** is disconnected first, and then the conductive layer **29** is used to bridge the disconnection. When the light is projected forward from below the substrate **20**, the light can pass through directly as shown in the arrows of FIG. 2J, avoiding the conventional metal reflection problem as shown in FIG. 1. This is because the g-aSi region **231** has already been indented in the gate electrode **211**, the DL metal region **253** and the drain metal region **252** do not have the second metal layer **25** to create reflection and that the ITO used to electrically connect the DL metal region **253** and the drain metal region **252** is a transparent material. Therefore, the TFT displaying device manufactured according to the five-mask manufacturing method of

the first embodiment and the method of making the same effectively reduce photocurrent leakage.

#### Second Embodiment

5

Refer to FIGS. 3A~3H, which illustrate a manufacturing method of a TFT displaying device according to a second embodiment of the invention. In the second embodiment, a four-mask manufacturing process is employed to manufacture a displaying device. Besides, the same devices used in both the second embodiment and the first embodiment follow the same labeling

At first, a substrate **20** is formed, and a first metal layer **21** is formed on the substrate **20** as shown in FIG. 3A. Next, the first metal layer **21** is patterned to form the gate electrode **211**, and a gate insulating layer **22** is formed on the substrate **20** and covers the gate electrode **211** as shown in FIG. 3B. Then, an a-Si layer **23** is formed on the gate insulating layer, and a doped a-Si layer such as an n+ a-Si layer **24** for instance is formed on the a-Si layer **23** as shown in FIG. 3C.

Afterwards, a second metal layer **25** is formed on the doped a-Si layer **24** as shown in FIG. 3D. Next, the second metal layer **25**, the doped a-Si layer **24** and the a-Si layer **23** are patterned to form a source metal region **251**, a drain metal region **252**, a DL metal region **253**, a doped g-aSi region **241**, a doped DL-aSi region **242**, the g-aSi region **231** and data-line a-Si region **232**, as shown in FIG. 3E.

In FIG. 3E, a channel region **26** exists between the source metal region **251** and the drain metal region **252**, and the source metal region **251** and the drain metal region **252** are correspondingly formed above the gate electrode **211**. The DL metal region **253** and the drain metal region **252** are separated at an interval from each other. The data-line a-Si region **232** is formed below the DL metal region **253** and corresponds to the width of the DL metal region **253**.

Then, a passivation layer **27** is formed on the gate insulating layer **22** and covers the source metal region **251**, the drain metal region **252** and the DL metal region **253** as shown in FIG. 3F.

Next, a first via **271**, a second via **272** and a third via **273** are formed on the passivation layer **27** for respectively exposing partial surfaces of the DL metal region **253**, the drain metal region **252** and the source metal region **251** as shown in FIG. 3G.

At last, a conductive layer **29** is formed on the passivation layer **27** and covers the first via **271**, the second via **272** and the third via **273**. The second via **272** and the third via **273** respectively formed on the drain metal region **252** and the source metal region **251** are electrically isolated as shown in FIG. 3H. The conductive layer **29** can be made of indium tin oxide (ITO) for instance.

FIG. 3H is a cross-sectional view of a TFT displaying device according to the second embodiment of the invention. In the second embodiment, the DL metal region **253** and the drain metal region **252** are electrically isolated; that is, the second metal layer **25** is disconnected first. The conductive layer **29** is then used to bridge the disconnection. The DL metal region **253** and the drain metal region **252** are electrically connected, but the drain metal region **252** and the source metal region **251** are electrically isolated. When the light is projected forward from below the substrate **20**, the light can pass through directly as shown in the arrows of FIG. 3H, avoiding the conventional metal reflection problem as shown in FIG. 1. This is because the g-aSi region **231** has already been indented in the gate electrode **211**, the DL metal region **253** and the drain metal region **252** do not have the second metal layer **25** to create reflection and that the ITO used to

## 5

electrically connect the DL metal region **253** and the drain metal region **252** is a transparent material. Therefore, the TFT displaying device manufactured according to the five-mask manufacturing method of the second embodiment and the method of making the same effectively reduce photocurrent leakage.

While the invention has been described by way of example and in terms of a preferred embodiment, it is to be understood that the invention is not limited thereto. On the contrary, it is intended to cover various modifications and similar arrangements and procedures, and the scope of the appended claims therefore should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements and procedures.

What is claimed is:

**1.** A displaying device, comprising:

a substrate;

a gate electrode formed on the substrate;

a gate insulating layer covering the gate electrode;

a gate amorphous silicon region (g-aSi) formed on the gate insulating layer and correspondingly positioned above the gate electrode;

a source metal region and a drain metal region formed on the g-aSi region;

a data-line (DL) metal region directly connecting with a data line and formed on the gate insulating layer, wherein the DL metal region is separated from the drain metal region at an interval;

a passivation layer formed on the gate insulating layer and covering the source metal region, the drain metal region and the DL metal region, wherein the passivation layer comprises a first via and a second via for respectively exposing partial surfaces of the DL metal region and partial surfaces of the drain metal region; and

a continuous conductive layer formed on the passivation layer and covering the first via and the second via such that the DL metal region is electrically connected to the drain metal region via the continuous conductive layer.

**2.** The displaying device according to claim **1**, further comprising a doped g-aSi region formed on the g-aSi region and located under the source metal region and the drain metal region.

**3.** The displaying device according to claim **1**, wherein an area of the g-aSi region is smaller than an area of the gate electrode positioned therebelow.

**4.** The displaying device according to claim **1**, wherein the gate insulating layer comprises a silicon nitride layer.

**5.** The displaying device according to claim **1**, wherein the conductive layer comprises an indium tin oxide (ITO) layer.

**6.** The displaying device according to claim **1**, further comprising a data-line a-Si region, wherein the DL metal region is formed on the data-line a-Si region.

**7.** The displaying device according to claim **6**, further comprising a doped DL-aSi region between the DL metal region and the data-line a-Si region.

**8.** The displaying device according to claim **6**, wherein the passivation layer further comprises a third via for exposing partial surfaces of the source metal region.

**9.** The displaying device according to claim **6**, wherein the conductive layer further covers the third via, and the second via and the third via are electrically isolated.

**10.** A displaying device, comprising:

a substrate;

a gate electrode formed on the substrate;

a gate insulating layer covering the gate electrode;

## 6

a gate amorphous silicon region (g-aSi) formed on the gate insulating layer and correspondingly positioned above the gate electrode;

a source metal region and a drain metal region formed on the g-aSi region;

a data-line (DL) metal region directly connecting with a data line and formed on the gate insulating layer, wherein the DL metal region and the drain metal region are located at the same side of the source metal region and the DL metal region is separated from the drain metal region at an interval;

a passivation layer formed on the gate insulating layer and covering the source metal region, the drain metal region and the DL metal region, wherein the passivation layer comprises a first via and a second via for respectively exposing partial surfaces of the DL metal region and partial surfaces of the drain metal region; and

a conductive layer formed on the passivation layer and covering the first via and the second via for electrically connecting the DL metal region and the drain metal region.

**11.** A displaying device, comprising:

a substrate;

a gate electrode formed on the substrate;

a gate insulating layer covering the gate electrode;

a gate amorphous silicon region (g-aSi) formed on the gate insulating layer and correspondingly positioned above the gate electrode;

a source metal region and a drain metal region formed on the g-aSi region, wherein the drain metal region is completely overlapped with the gate electrode;

a data-line (DL) metal region, wherein the DL metal region is separated from the drain metal region at an interval;

a passivation layer formed on the gate insulating layer and covering the source metal region, the drain metal region and the DL metal region, wherein the passivation layer comprises a first via and a second via for respectively exposing partial surfaces of the DL metal region and partial surfaces of the drain metal region; and

a continuous conductive layer formed on the passivation layer and covering the first via and the second via such that the DL metal region is electrically connected to the drain metal region via the continuous conductive layer.

**12.** A displaying device, comprising:

a substrate;

a gate electrode formed on the substrate;

a gate insulating layer covering the gate electrode;

a gate amorphous silicon region (g-aSi) formed on the gate insulating layer and correspondingly positioned above the gate electrode;

a source metal region and a drain metal region formed on the g-aSi region, wherein the drain metal region is completely overlapped with the gate electrode;

a data-line (DL) metal region, wherein the DL metal region and the drain metal region are located at the same side of the source metal region and the DL metal region is separated from the drain metal region at an interval;

a passivation layer formed on the gate insulating layer and covering the source metal region, the drain metal region and the DL metal region, wherein the passivation layer comprises a first via and a second via for respectively exposing partial surfaces of the DL metal region and partial surfaces of the drain metal region; and

a conductive layer formed on the passivation layer and covering the first via and the second via for electrically connecting the DL metal region and the drain metal region.

7

13. A displaying device, comprising:  
 a substrate;  
 a gate electrode formed on the substrate;  
 a gate insulating layer covering the gate electrode;  
 a gate amorphous silicon region (g-aSi) formed on the gate 5  
 insulating layer and correspondingly positioned above  
 the gate electrode;  
 a source metal region and a drain metal region formed on  
 the g-aSi region, wherein the source metal region is 10  
 directly connected to a pixel electrode;  
 a data-line (DL) metal region directly connecting with a  
 data line and formed on the gate insulating layer,  
 wherein the DL metal region is separated from the drain  
 metal region at an interval;  
 a passivation layer formed on the gate insulating layer and 15  
 covering the source metal region, the drain metal region  
 and the DL metal region, wherein the passivation layer  
 comprises a first via and a second via for respectively  
 exposing partial surfaces of the DL metal region and  
 partial surfaces of the drain metal region; and 20  
 a continuous conductive layer formed on the passivation  
 layer and covering the first via and the second via such  
 that the DL metal region is electrically connected to the  
 drain metal region via the continuous conductive layer.

8

14. A displaying device, comprising:  
 a substrate;  
 a gate electrode formed on the substrate;  
 a gate insulating layer covering the gate electrode;  
 a gate amorphous silicon region (g-aSi) formed on the gate  
 insulating layer and correspondingly positioned above  
 the gate electrode;  
 a source metal region and a drain metal region formed on  
 the g-aSi region;  
 a data-line (DL) metal region being a part of a data line and  
 formed on the gate insulating layer, wherein the DL  
 metal region is separated from the drain metal region at  
 an interval;  
 a passivation layer formed on the gate insulating layer and  
 covering the source metal region, the drain metal region  
 and the DL metal region, wherein the passivation layer  
 comprises a first via and a second via for respectively  
 exposing partial surfaces of the DL metal region and  
 partial surfaces of the drain metal region; and  
 a continuous conductive layer formed on the passivation  
 layer and covering the first via and the second via such  
 that the DL metal region is electrically connected to the  
 drain metal region via the continuous conductive layer.

\* \* \* \* \*